Note on calculation of EOL-RIR and EOL-RR for the CRM "phosphate rock"

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Note on wording used in this document

"Phosphate rock" as a CRM is a surrogate for "phosphorus, the element, in whatever form" (organic, mineral, P4 – fertiliser, manure, phosphate rock, animal fodder, human food …). See discussion in ESPP Briefing Note of 15/1/2015.

In the text below we will use "phosphorus" to mean "the element in whatever form".

Definitions of EOL-RIR and EOL-RR

As indicated in JRC's email of 16/4/19:

- **EOL-RIR: end of life recycling input rate** - the fraction of secondary material in the total material input (primary and secondary) to the production system. It measures the proportion of total material available to manufacturers that comes from recycling of end-of-life products.
- **EOL-RR: end of life recycling rate** - the amount of (secondary) materials recovered at end-of-life compared to the overall waste quantities generated (output perspective). It provides information about the performance of the collection and recycling to recover materials at end-of-life and it is thus useful from a recyclers' perspective.

Note: EOL-RIR is identified in the JRC report on recycling indicators (EUR 29435 EN October 2018) as the "principle" recycling indicator for CRMs, with EOL-RR being a "complementary" recycling indicator, along with "possible forward looking recycling indicators" EOL-RIR (potential) and EOL-RR (potential).

The need to reconsider the calculation of EOL-RIR and EOL-RR for "phosphate rock" CRM

The Deloitte CRM Fact Sheet 2017 (first revision = second CRM list) concludes page 318 for phosphate rock:

- "*recycling input rate*" (presumably this is the EOL-RIR) = zero, because "*the input material phosphate rock is not recyclable*".
- But "*to illustrate opportunities … a recycling value of 17% is assumed*"

These two numbers (0% and 17%) are not helpful.

The core problem seems to be that the conceptual system on which the calculation of EOL-RIR is based is not appropriate for phosphate rock:

- it is based on systems boxes of: extraction, processing, manufacturing, use and collection. Significant flows in the phosphorus Material Systems Analysis (MSA) do not fit into these boxes (manure, animal fodder, …)
- the diagram (figure 1, JRC report cited above) is missing arrows (flows) which are significant for phosphorus. E.g.: collection in EU -> use in EU (manure collected then spread on fields), recycling in EU -> use in EU (directly to use without processing, e.g. struvite recovered in sewage works), use outside EU -> use in EU (import of animal fodder such as soya)

Challenges in application to "phosphate rock"

The following major challenges are posed for deriving 'numbers' for these two ratios for the CRM "phosphate rock"

A. Lack of reliable and recent data on phosphorus flows at the European level..
B. Distinct, but interrelated, system flows for phosphorus in agri-food production and consumption (fertilisers, animal fodder, livestock, food, sewage, manure …) and phosphorus in industrial – technical applications (detergents, toothpaste, cleaning products, drinking water treatment, fire safety, pesticides, electronics and metallurgy, etc).
C. Absence of data, and indeed challenges with definitions, for "recycling" (inc. re-use) of phosphorus in manure and in crop by-products (agricultural by-products generated on-farm).

Discussion A: lack of data

This problem is known. The problem is probably applicable to other CRMs. ESPP engaged work on this problem for phosphorus, with the DONUTSS workshop (3-4 September 2015), see conclusions online at www.phosphorusplatform.eu/DONTUSS

However, to date the most recent phosphorus flow data for Europe remain those of K. Van Dijk, J. Lesschen & O. Oenema 2016 (estimates for 2005 - 2010 data) http://dx.doi.org/10.1016/j.scitotenv.2015.08.048

With appropriate funding, this could be updated: the model is there and for part of the data more recent data is available.

ESPP suggests that EU action is needed to address this lack of data and to ensure regular update of data, by defining a number of phosphorus flows for which data should be collected and establishing a system for collecting and collating this data.

In particular, there is a need to monitor and develop reliable data for recycling from different secondary sources into different new products, for example: phosphorus salts (e.g. struvite), ashes (e.g. based on sewage sludge and meat and bone meal) and biochars (e.g. all kind of sources).

Addressing the overall lack of data and updating data would enable the establishment of indicators for CRM policy, for Circular Economy policy and for Bio-Economy policy.

The objective should be integration of pertinent data on phosphorus flows into the EU RMIS (Raw Materials Information System), see JRC report on recycling indicators (see above).

Discussion B: industry vs. agri-food phosphorus flows

ESPP proposes to address this by ignoring the industry use of phosphorus in the calculation of EIR-RIR and EIR-RR for "phosphate rock". As regards phosphorus imported into Europe (in whatever form), the use of phosphorus in mineral fertilisers and animal feed (mineral phosphate feed additives plus phosphorus in imported animal fodder) is >90%. This figure was lower in the past when 5-10% of use was in detergents, but this use has been very drastically reduced with the bans on phosphate in domestic laundry and dishwasher detergents. The remaining <10% is, we would suggest, probably smaller than the degree of error in estimates of phosphorus flows.

We note that certain industrial uses (even if quantities are relatively small) could be included in the analysis of the agri-food system, because they are used directly in food or end-up in raw sewage: mineral phosphate food additives, pharmaceuticals, toothpastes, cleaning products, drinking water treatment. Estimates are available for usage in these applications, and the use-route is known. Their fate in sewage will be the same as other phosphorus entering sewage. Therefore, these uses could be added into the proposed 'concept' below without significant difficulty. We have not done this for the present because (a) it complicates understanding and (b) the total quantity (<10% of agri-food flows) is not significant.

Similarly, phosphorus used in pesticides and herbicides (e.g. glyphosate) could be added (enters the agri-food system, but not directly sewage), but again the quantity is not significant (probably <5% of P flows).

Discussion C: definition of "recycling" of manure and crop by-products

This is a key question. The quantity of phosphorus going to agriculture in manure is similar to the total imported phosphorus into the EU (Van Dijk et a. 2016 as above), both 1 700 – 1 800 ktP/y. The treatment of this flow in the calculation will thus radically modify the results.

However, it is unclear how to take manure into account for the following reasons:

- There is no data available to estimate what proportion of manure is in fact returned to fields, and what proportion is lost. For example, if cows' drinking point is in a river on the edge of the field, a significant amount of manure will be lost into the river (polluting downstream), especially in hot weather when the cows spend time cooling in the water. Some manure phosphorus may also be lost in runoff during manure storage.
- Some manure phosphorus will be lost in rain runoff from grazing fields (the manure is returned to the field, but then partly washed away), but the same situation applies for applied mineral fertilisers (albeit the percentage losses may be different).
- It could be argued that the return of manure* to a field does not mean it is effectively recycled or reused. Manure may be returned to a field beyond the (potential) needs of the crop (either directly, through intensive grazing on the field – manure straight from the animals, and/or after storage by spreading). The situation is not the same for mineral fertilisers, which farmers will generally not use beyond the (potential) needs of the crop. It could be argued that manure returned beyond crop needs is not "recycled" (even if a significant part will be held and stored in soil and may be taken up by crops in future years).

* Note: the situation for manure is different from other organic recycled flows, such as sewage biosolids. Most manure is returned directly to the field (cow in field) or "spread" up to limits (e.g. Nitrates Directive), whereas other organic recycled flows are generally only used on fields as appropriate for crop needs (that is effectively used as and replacing fertiliser: e.g. sewage biosolids, digestate …)

We also note, that the quantity of phosphorus in total EU manure production is an estimate based mainly on data for animal numbers, estimates of phosphorus content of different types of livestock manure. The estimated amount of phosphorus in final products and byproducts (e.g. milk, eggs, meat, bones, blood etc) can also be taken into account. The animal number data are probably reasonably accurate, but the manure phosphorus content estimates are very approximate. Phosphorus content of manure depends directly on the livestock diet. This may differ significantly between extensive grazing livestock and intensive housed production. Also diet phosphorus contents have changed over recent years with increasing use of phytase, which improves digestability of phosphorus in feed, so reducing the amount of phosphorus needed in the feed.

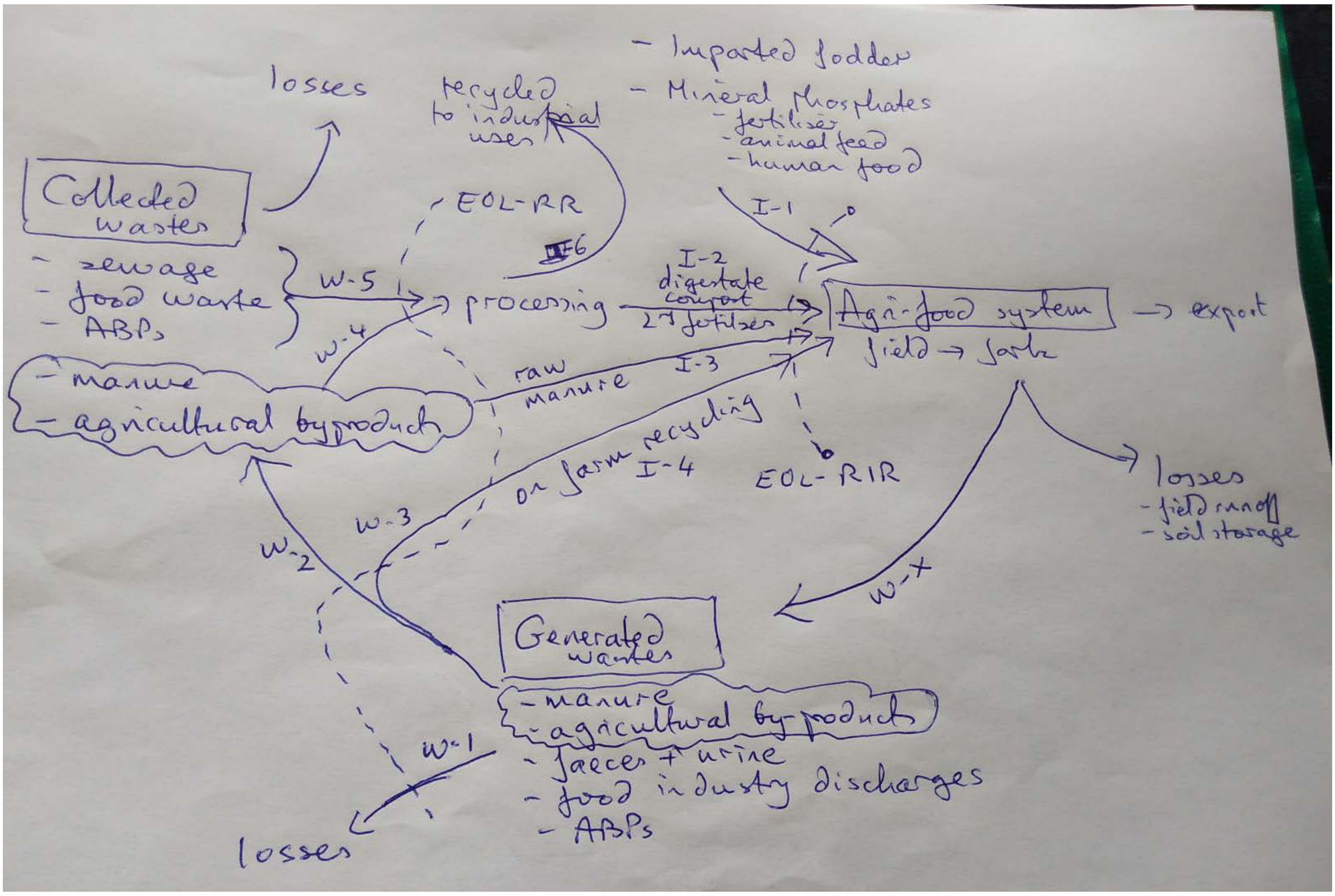
The situation described above is also true for crop residues generated on the farm, but the quantities of phosphorus are considerably lower than in manures. This concerns crop residues such a straw, sugar beet tops and other unused parts of crop plants. Phosphorus in cover crops, which are ploughed back into the soil, could also be considered as recycling, or could be ignored as not of relevance for a food-systems analysis.

The approach used in van Dijk et al. 2016 (cited above) is to consider only crop residues which are collected and which leave the field (not those left in the soil or ploughed back in-situ).

<u>Proposed approach to calculate EIR-RIR and EIR-RR for "phosphate rock</u>

We propose the following simplified phosphorus systems diagram, with the objective of clarifying how to calculate EIR-RIR and EIR-RR for "phosphate rock", noting that

- The problem of lack of data and outdated data needs to be addressed, see above.
- As indicated above, industrial (non agri-food) uses of phosphorus are not included at present (could be added later).
- A key challenge is how to take into account manure returning to fields, as discussed above



EIR-RIR

This is the percentage of phosphorus being used in the agri-food system which comes from secondary sources.

In the diagram below, if crop residues (but not manure) not removed from the field (I4) are ignored, as suggested above:

EIR-RIR = (I2 +M x I3) / (I1 + I2 + I3)

We suggest to organise a discussion between agronomists, fertiliser experts and the farming community as to whether M should be fixed at 100%, or if not how it should be fixed, and to define feasible and reliable indicators on which calculation of M should be based (these indicators should enable to identify improvements in agricultural practice in manure management).

EIR-RIR

This is the % of phosphorus in collected wastes which is recycled.

In the diagram below, again ignoring crop residues not removed from the field (I4), we suggest to define two different ratios

- **EIR-RR [technical]** = % of phosphorus in collected waste which is processed to generate fertiliser products or industrial products ("technical phosphorus recovery")
  = (W4 + W5) / W2
  = (I2 + I6) / W2
- **EIR-RR [reuse]** = % of phosphorus in generated waste which is collected and then either processed (as above) or directly reused
  = (I2 + M x I3 + I6) / (W2 + W1)
  = (I2 + M x I3 + I6) / WX

We suggest to organise a discussion between concerned stakeholders, researchers, JRC and DG GROW (Circular Economy policy) to assess the above, or propose other modes of calculation, which could provide:

- meaningful ratios as indicators of criticality of "phosphate rock"
- comparable to the EIR-RIR and EIR-RR for other CRMs (compatible with JRC methodology)
- feasible and reliable in terms of data collection and reliability
- usefulness as indicators of achievement of Circular Economy objectives

ESPP proposes that JRC and/or ESPP organise (or co-organise with DG GROW, EEA and with industry stakeholders) one or more workshop(s) in Brussels to discuss the above questions with stakeholders, phosphorus flow scientists and experts, with the objective of achieving consensus and industry engagement:
- data reliability and updating
- calculation of manure recycling rate (M)
- adaptation of EOL-RR and EOL-RIR calculation for 'phosphate rock'